Bluetooth Wireless

(File: Bluetooth.wpd, Update 08/03/00)

Synopsis:
Bluetooth is an extremely low cost, wireless & seamless local area network (WLAN) technology using robust radio frequency technology. It is designed to be built into and connect electronic appliances without adding significant cost. Ideally Bluetooth would only add a single IC chip to the device.

To date Bluetooth has seen almost no implementation but development work is proceeding rapidly. As with many technology advances, the hype exceeded the reality and the complexities are more severe than expected.

Here is a summary of the market, Bluetooth specifications, operation of the systems, developers, and predicted products. Current delaying issues are discussed at the end.

Summary Facts:

Timing:	Market was expected to explode in 2000. The magic $5 mark might not be reached until 2004.
Growth projection:	173% compound annual growth rate (CAGR), may be understated
Market projection:	$1.65 billion by 2002, $2 billion by 2005
Paradigm:	Shift from premise based to person-based communications. A universal bridge between existing data networks, a peripheral interface and means of forming small private ad hock groupings of connected devices.
Prime developers:	IBM, Intel, Nokia, Toshiba = Original SIG
Promoters Group:	Originators +, Microsoft, 3Com, Lucent, Motorola
SIG membership:	Over 1800 members (all can use standard without royalties).
Web Site:	www.bluetooth.com
Standards:	IEEE 802.15 (not yet adopted) Bluetooth Special Interest Group version 1.0 An upgraded version 2.0 with higher bandwidth and resolution of interoperability issues is being considered.
Device Cost:	Chip sets are currently $30. Expect: $5 - $10 eventually. Concept success is pegged to $5 cost.
Range:	10 meters (through walls & briefcases)
Spectrum:	2,400 to 2,483.5 MHz in the U.S., unlicenced, ISM band
Technology:	fast frequency-hopping, spread-spectrum (FHSS) Employs Time Division Duplexing (TDD)

	Frequency hope rate is 1660 hops/second
Channels:	79, 1 MHz wide hop channels
Modulation:	Frequency-Shift keying (FSK)
Date types:	Voice & Data supported.
Transmission rate:	1 Mbit/s, raw bit rate, range 10 meters current system 10-20 Mbits/s (future), range 50 meters but uncertain
Data rate:	721 kbits/s (asymmetric), 432.6 kbits/s (symmetric).
Voice data rate:	64 kbits/s in synchronous mode using CVSD voice coding. Voice packets are never retransmitted. CVSD coded voice is quite audible even with 4% bit-error rate.
Dual mode:	Simultaneous transmission of one synchronous data channel along with three synchronous voice audio channels is supported. Also supported is simultaneous transmission of asynchronous data and synchronous voice audio data within a single channle.
I/O:	USB supported.
FEC	Forward Error Correction (FEC) in Bluetooth helps reduce impact of interference since noisy channels are skipped in next frequency hop sequence.
Antennas	The antenna for most Bluetooth devices is on the PC board.
Network Design:	Ad-hoc network of master & slaves called a Piconet.
Nodes:	Eight, with up to 7 active slaves per master within a Piconet. Individual Bluetooth units identify themselves within seconds using a 48-bit serial number. The first device becomes the master. Once a Piconet is established, all nodes use the same bit hopping sequence.
Slave Modes:	There are three power saving modes for idle devices. In order of power savings these modes are: PARK, HOLD, SNIFF. The master can command slaves to go quite and then wake them up. In park these devices need only about 2 mW to stay operational. This makes them well suited for battery operations.
Sniff mode:	In sniff mode, the slave listens within its Piconet at a reduced scan rate (programmable).

Park mode:	In park mode, the slave is still synchronized within the network, but doesn t participate in data transmission. Devices in this mode only occasionally listen to maintain synchronization and for a wake up call. This is the maximum power saving mode.
Hold mode:	In hold mode, only an internal timer circuit keeps on working. Slaves can request the master to allow them to go into hold mode.
Scatternets:	Piconets can be interconnected into a larger multiple-Piconet environment known as a Scatternet. Scatternet communications takes place between the Piconet masters. This technique can extend range of the system.
Listening:	At startup, all devices within a Piconet are in standby mode. Every 1.28 seconds, they listen for any kind of signal. If a signal is detected, the device will look for a potential partner on 32 individually assigned frequencies.
Wake-up	Usual wake-up time needed to establish a link between master and slave is .64 seconds. The maximum time delay is 2.56 seconds.
Telegrams:	Inquiry telegrams are used by the master to identify nearby Bluetooth devices (like printers or fax machines).
OS Support (MS):	Will have to wait for next version of Bluetooth specifications.
Service-discovery	This feature will allow auto detection of nearby devices. & available services. This will allow very easy access to pubic access devices like printers, projectors, LAN access devices.
MS product:	Mobile Explorer Microbrowser planned
Interoperability:	In spec (v1.0), but all issues not resolved. v2.0 standard is under development. It will include auto handover to next access point for voice applications. Speed increases also likely (2 - 20 Mbits/sec under discussion).
Interop Specs:	Called Profiles
Power requirements	Two levels in spec. (EIRP = effective Isotropic radiant power) 1 milliwatt EIRP for 10 meter range 100 milliwatt EIRP for 100 meter range
Receiver	Input sensitivity of -70 dBm working with an IF of 1 MHz.

Alternate Technologies	Ethernet (CAT-5) Dominant LAN technology 802.11 wireless Ethernet Designed for business market, pricey. HomeRF Home LAN, May become compatible with Bluetooth Low end version of 802.11 HomePNA Home LAN Powerline Uses home power cabling DECT - Digital European Cordless Telecommunications
Developers:	Silicon Wave, San Diego, CA, www.siliconwave.com, -- RF chip SiW015, and SiW016 link controller chip. Cambridge Silicon Radio, www.CambridgeSiliconRadio.com, CSR (Cambridge, UK) BlueCore single chip solution Philsar Semiconductor, www.philsar.com, -- PH2401 Radio chip, and Mitel MT1020A baseband IC Lucent Technologies, www.lucent.com/micro, W7020 radio chip, & W7400, baseband controller (uP core), Ericsson AB, www.ericsson.com, chips & modules, PBA 313 01, 45 mA Philips Semiconductor, www.semiconductors.phillips.com, chips, UAA355a RE transceiver, VWS2602 baseband chip. Intel laptop synro systems 3Q00 Extended Systems Profiles Arca Technologies (Digital Engineering Ltd) Profile Analyzer software, 3Q00 IVT Corp, Dallas Protocol stacks & development tools SSL, San Jose, CA antenna to host interface solutions National Semiconductor LMX3162 transceiver IC, LMX5001 link/baseband controller. Innovent Systems Inc., El Segundo, CA (Broadcom Corp) -- single-chip Bluetooth radio, www.innoventsystems.com Atmel Cypress Oki Electric Industry, CMOS chipset, 07/00, production by 1Q/01

Likely Products:

Portable phones
Wireless PDA (Palm, Handspring) as control center
Laptop computer to printer & ad hoc LAN link
PCMCIA Bluetooth modem
GSM phone
Digital camera downloads (Kodak pushing for 10 Mbps)
Video cameras
PDA to cell phone phone # transfer
Cell phone wireless headset
Cell phone to laptop wireless connection
eBook content refresh
TV remote & web TV remote
Smart security badge
eCash (wireless credit card)
Electronic lock entry (house & car)
Breath tester for police use
Signature capture device
Entertainment robots
Toys (RF controlled vehicles)

Current Products: None

Almost Products: LM Ericsson has demonstrated Bluetooth headset. 3/00

Xircom Inc has demonstrated Bluetooth PC cards (PCMCIA) 3/00

Sharp has developed a wireless remote camcorder which displays audio & video through a remote controller. The application is not strictly compatible with the Bluetooth standard since it pushes transmission rates to 10 Mbits/sec which is necessary for serious video links. The device also uses higher power transmissions (400 mA on transmit) than the currently Bluetooth standard. It uses direct-spectrum transmission rather than frequency-hopping. Sharp is hoping their solutions are added to the upper end of the v1 standard. Product release scheduled for fall 2000. (6/00)

Palm plans to implement Bluetooth as attachable devices until the price falls enough for embedded use (7/00).

HP expects to offer PCI based Bluetooth products for desktops in 2000 (7/00).

IBM is focused on USB based Bluetooth devices (7/00).

DELAY ISSUES:

1. **RFI Issues** -- Bluetooth & 802.11 wireless LANS use the same 2.4 GHz spectrum. Interference is expected to disrupt 802.11 communications, not vis versa because fast hop rate of Bluetooth. The effect is dramatic reduction in throughput. Solutions are underway, one of which is Bluetooth version 2 which would operate at 5 GHz.

   There are also jamming problems related to using Bluetooth devices next to higher power 900 - 1800 MHz transceiver inside a cellular handset.

   The FAA is also concerned over Bluetooth transmissions on airline navigation channels and France has banned Bluetooth due to RFI on defense channels.

2. **Interoperability** The specification is complex enough to allow interoperability issues as developers work to create competing devices. These problems should eventually go away as the market weeds out non-interoperable solutions.

3. **Costs** The driving idea behind Bluetooth as a cable replacement was based on the idea that adoption would only occur if overall price addition was between $5 and $10. So far, just the Bluetooth chip sets are $30. Predictions are that costs will not hit the $5 range until 2004 or 2005.

4. **Feature Creep** As more developers entered the effort, the demand for more features increased. Considerable complexity was added by networking functionality and yet not all applications require sophisticated networking. Development and testing of these complex features have added considerable more development time than expected.

5. **Version Envy** The proposed version 2, which greatly increases throughput, eliminates RFI and adds other features may be delaying version 1, since there is a tendency to wait for the more robust solution.

SOURCES: Electronic Engineering Times , 3/00, 4/00, 5/00, 6/26/00.
Electronic Design, 5/00, 7/24/00,
Wireless Systems Design, etc.
InfoWorld 7/10/00,
Wireless Systems Design, 7/00